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(71) Applicant: **Delphi Technologies, Inc.**
Troy, MI 48007 (US)

(72) Inventor: **Kunkulagunta, Koteswara Rao**
Rainham, Kent ME8 7BT (GB)

(74) Representative: **Pople, Joanne Selina**
Marks & Clerk,
Alpha Tower,
Suffolk Street
Queensway, Birmingham B1 1TT (GB)

(54) Fuel injector

(57) A fuel injector comprising an outer valve needle (14) provided with a bore (17), an inner valve needle (18) slidable within the bore (17), the outer and inner valve needles (14, 17) being engageable with first and second seatings (13, 21) respectively to control the supply of fuel from the fuel injector. The inner valve needle (18) includes a passage (26, 28) which communicates with a sac chamber (23) located downstream of the second seating (21), whereby movement of the outer valve needle (14) away from the first seating (13) causes fuel to flow through the passage (26, 28) into the sac chamber (23) such that fuel pressure within the sac chamber (23) causes the inner valve needle (18) to lift away from the second seating (21).

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Description

[0001] This invention relates to a fuel injector for use in supplying fuel, under pressure, to a combustion space of a compression ignition internal combustion engine.

[0002] In order to reduce emissions levels, it is known to provide fuel injectors in which the total area of the openings through which fuel is delivered can be varied, in use. One technique for achieving this is to use two valve needles, an outer valve needle which is slidable within a bore formed in a nozzle body and an inner valve needle which is slidable within a bore provided in the outer valve needle. Movement of the outer valve needle controls the supply of fuel to some of the outlet openings formed in the nozzle body, whereas movement of the inner valve needle controls the supply of fuel to other outlet openings formed in the nozzle body.

[0003] European patent application EP 99304430.4 describes a fuel injector of the aforementioned type in which movement of both the inner and outer valve needles is controlled by a single actuator. The bore in the outer valve needle is provided with a step which is engageable with an enlarged upper end region of the inner valve needle. In use, when the outer valve needle is lifted in an upwards direction away from a first valve seating by a relatively small amount, a first set of outlet openings are exposed, causing fuel to be ejected therefrom. Upward movement of the outer valve needle by a further amount causes the inner valve needle to engage the step such that movement of the outer valve needle is transmitted to the inner valve needle. This causes the inner valve needle to lift away from a second seating, exposing a second set of outlet openings from which fuel is then ejected. This provides a higher fuel delivery rate.

[0004] It is an object of the invention to provide a fuel injector in which movement of the outer valve needle is transmitted to the inner valve needle by alternative means.

[0005] According to the present invention there is provided a fuel injector comprising an outer valve needle provided with a bore, an inner valve needle slidable within the bore, the outer and inner valve needles being engageable with first and second seatings respectively to control the supply of fuel from the fuel injector, the inner valve needle having a passage formed therein communicating with a sac chamber located downstream of the second seating, whereby movement of the outer valve needle away from the first seating causes fuel to flow through the passage into the sac chamber such that fuel pressure within the chamber causes the inner valve needle to lift away from the second seating.

[0006] Conveniently, initial movement of the outer valve needle away from the first seating by a relatively small amount to a first fuel injecting position causes a first set of outlet openings to be exposed from which fuel is then ejected, and further movement of the outer valve needle to a second fuel injecting position causes inner valve needle movement away from the second seating, thereby causing a second set of outlet openings to be exposed from which fuel is then ejected. By transmitting movement of the outer valve needle to the inner valve needle solely by increasing the fuel pressure within the sac chamber, the fuel injector is caused to move into a relatively stable second fuel injecting position.

[0007] This provides an advantage over known fuel injectors in which the second fuel injecting position can be relatively unstable.

[0008] Conveniently, the outer valve needle is slidable within a further bore provided in a nozzle body and the inner valve needle may be provided with an axially extending passage communicating with one or more radially extending passages provided in the inner valve needle, movement of the outer valve needle within the further bore away from the first seating causing the end of the or each radially extending passage to be exposed to permit fuel to flow into the sac chamber.

[0009] The invention will now be described, by way of example only, with reference to the accompanying drawing, in which there is shown a sectional view of a fuel injector in accordance with the present invention.

[0010] Referring to the accompanying drawing, the fuel injector includes a nozzle body 10 provided with a blind bore 12. Adjacent the blind end of the bore, the bore 12 is shaped to define a first seating 13 of substantially frusto-conical shape. An outer valve needle 14 is slidable within the bore 12, the outer valve needle 14 being engageable with the first seating 13 to control fuel flow through a first set of outlet openings 16. Although not illustrated in the accompanying drawing, the upper end of the outer valve needle 14 is shaped to be of diameter substantially equal to that of the adjacent part of the bore 12 so as to form a substantially fluid tight seal therewith and to guide the outer valve needle 14 for sliding movement within the bore 12. Additionally, a spring (not shown), or other biasing means, is located at the upper end of the outer valve needle 14 and serves to bias the outer valve needle 14 in a downwards direction against the first seating 13. Movement of the outer valve needle 14 in an upwards direction is controlled by means of an actuator arrangement (not shown) located at the upper end of the outer valve needle 14 such as, for example, an electromagnetic actuator arrangement.

[0011] The outer valve needle 14 is provided with an axially extending bore 17 within which an inner valve needle 18 is slidable. The blind end of the bore 17 defines, with an upper end of the inner valve needle member 18, a spring chamber 19 which houses a compression spring 20. The compression spring 20 biases the inner valve needle 18 in a downwards direction against a second seating 21, of substantially frusto-conical shape, defined by the blind end of the bore 12. The inner valve needle 18 is engageable with the second seating 21 to control fuel flow through a second set of outlet openings 22 downstream of the first set of outlet openings 16. A sac region or sac chamber 23 is defined by the blind end of the bore 12 and the end of the inner

valve needle 18 remote from the spring chamber 19. A delivery chamber 24 is defined by the bore 12 and the outer surface of the outer valve needle 14.

[0012] The inner valve needle 18 is provided with an axially extending passage 26 which communicates with the sac region 23. The inner valve needle 18 is also provided with passages 28 which extend radially from the passage 26 such that, when the inner valve needle 18 and the outer valve needle 14 are seated against their respective seatings, the ends 28a of the passages 28 are closed by the bore 17.

[0013] In use, fuel is supplied to the delivery chamber 24 from a source of fuel under high pressure. With the outer valve needle 14 seated against the first seating 13 and the inner valve needle 18 seated against the second seating 21, it will be appreciated that fuel in the delivery chamber 24 is unable to flow past the first seating 13 into the chamber 27. Thus, fuel injection into the engine cylinder does not take place. If the actuator is energized such that the outer valve needle 14 is moved in an upwards direction by a relatively small mount, causing the outer valve needle 14 to be lifted from the first seating 13, fuel in the delivery chamber 24 is able to flow past the first seating 13 into the chamber 27 and through the first set of outlet openings 16. The inner valve needle 18 remains seated against the second seating 21 due to the force of the spring 20. As fuel is unable to flow past the second seating 21 into the sac region 23, fuel is not ejected from the second set of outlet openings 22. In such circumstances, it will therefore be appreciated that fuel injection occurs at a relatively low rate.

[0014] In order to cease fuel injection the actuator is de-energized, causing the outer valve needle 14 to move back against the first seating 13 under the action of the spring force applied at its upper end. Fuel in the delivery chamber 24 is then no longer able to flow past the first seating 13 into the chamber 27 and fuel injection does not take place.

[0015] Alternatively, from the first injecting position, in which the outer valve needle 14 is lifted away from the first seating 13 by a relatively small amount, the actuator may be energized such that the outer valve needle 14 is moved away from the first seating 13 by a further amount. This causes the ends 28a of the passages 28 to be exposed to fuel in the chamber 27, causing a small amount of fuel within the chamber 27 to flow through the passages 28, into the passage 26 and subsequently into the sac region 23. At this stage, a small amount of fuel is able to flow through the second group of outlet openings 22 into the engine cylinder.

[0016] Initially, as fuel flows into the sac region 23 through the relatively narrow passages 26, 28 provided in the inner valve needle 18, the amount of fuel ejected from the second group of outlet openings 22 will be relatively small. However, as fuel pressure increases within the sac region 23, an upwards force is applied to the inner valve needle 18 which opposes the spring force applied by the spring 20. When fuel pressure in the sac region 23 overcomes the spring force, the inner valve needle 18 is lifted away from the second seating 21. Fuel in the chambers 24,27 is therefore able to flow directly into the sac region 23 past the second seating 21 and, thus, out through the second group of outlet openings 22. At this stage, the rate of fuel injection through the second group of outlet openings 22 is increased. It will therefore be appreciated that fuel injection occurs at a relatively high rate.

[0017] In order to cease fuel injection, the actuator is de-energized, causing the outer valve needle 14 to move back against the first seating 13 under the spring force applied to its upper end. Downward movement of the outer valve needle 14 closes the ends 28a of the passages 28, preventing further fuel flow between the chamber 27 and the sac region 23. Thus, fuel pressure in the sac region 23 is reduced and the inner valve needle 18 moves downwardly under the action of the spring 20 to seat against the second seating 21. The inner and outer valve needles 18,14 therefore return to the seated positions shown in the accompanying drawing.

[0018] The inner valve needle 18 forms a substantially fluid tight seal with the bore 17, thus, in use, fuel is unable to flow to or from the spring chamber 19 or such a flow of fuel is limited to a very low rate. The spring chamber 19 is of relatively large volume. Thus, relative movement of the needles 14,18 has relatively little effect upon fuel pressure within the spring chamber 19, the effect being insufficient to impede operation of the injector.

[0019] It will be appreciated that alternative bias means may be provided, in place of the compression spring 20, to bias the inner valve needle 18 against the second seating 21. Additionally, it will be appreciated that additional passages may be provided in the inner valve needle 18 to increase the rate at which fuel flows from the chamber 27 into the sac region 23 as the outer valve needle 14 is lifted away from the first seating 13 and uncovers the ends 28a of the passages 28.

[0020] Each set of first and second outlet openings 16,22 may include more than two outlet openings. Alternatively, a single first outlet opening and a single second outlet opening may be provided.

Claims

1. A fuel injector comprising an outer valve needle (14) provided with a bore (17), an inner valve needle (18) slidable within the bore (17), the outer and inner valve needles (14, 17) being engageable with first and second seatings (13, 21) respectively to control the supply of fuel from the fuel injector, the inner valve needle (18) having a passage (26, 28) formed therein communicating with a sac chamber (23) located downstream of the second seating (21), whereby movement of the outer valve needle (14) away from the first seating (13) causes fuel to flow through the passage (26, 28) into the sac chamber

(23) such that fuel pressure within the sac chamber (23) causes the inner valve needle (18) to lift away from the second seating (21).

2. The fuel injector as claimed in Claim, wherein the injector is arranged such that initial movement of the outer valve needle (14) away from the first seating (13) by a relatively small amount to a first fuel injecting position causes a first set of outlet openings (16) to be exposed from which fuel is then ejected, and further movement of the outer valve needle (14) to a second fuel injecting position causes the inner valve needle (18) to move away from the second seating (21), thereby causing a second set of outlet openings (22) to be exposed from which fuel is then ejected.

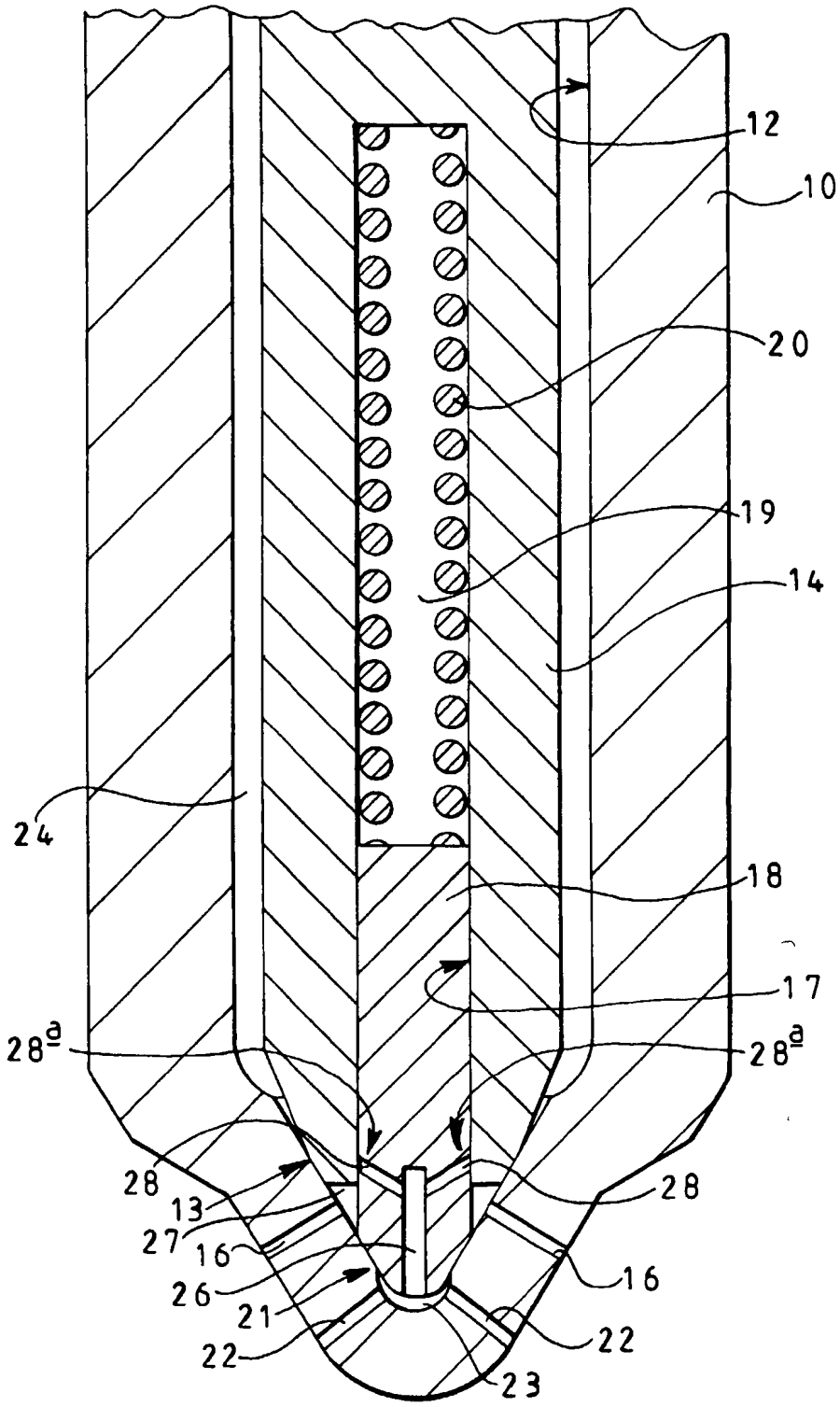
3. The fuel injector as claimed in Claim 1 or Claim 2, wherein the inner valve needle (18) is provided with an axially extending passage (26) communicating with one or more radially extending passages (28) provided in the inner valve needle (18).

4. The fuel injector as claimed in Claim 3, wherein the outer valve needle (14) is slidable within a further bore (12) provided in a nozzle body (10), the injector being arranged such that movement of the outer valve needle (14) within the further bore (12) away from the first seating (13) exposes the end (28a) of the or each radially extending passage (28) to permit fuel to flow into the sac chamber (23).

5. The fuel injector as claimed in any of Claims 1 to 4, further comprising a spring chamber (19) for housing a spring (20) which serves to urge the inner valve needle (18) against the second seating (21).

6. The fuel injector as claimed in Claim 5, wherein the inner valve needle (18) forms a substantially fluid tight seal with the bore (17) provided in the outer valve needle (14) such that the flow of fuel to or from the spring chamber (19) is substantially prevented.

7. The fuel injector as claimed in Claim 5, wherein the inner valve needle (18) is arranged within the outer valve needle (14) such that the flow of fuel to or from the spring chamber (19) is limited to a very low rate.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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 5317

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 September 2000	Hakhverdi, M

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 5317

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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